CLAIMS

What is claimed is:

1) Multicycle integration focal plane array (MIFPA), linear or area, which is a new type of electronic apparatus, and, unlike the existing FPA composed of a single-cycle integrator, is composed of

a) a correlated multicycle integrator that can be incorporated into an integrated circuit for each pixel of the MIFPA;

b) signal **10** being modulated either passively by a mechanical or electronic chopper **11** or actively by a pulsed light source **15**;

c) background (and/or dark current) **14** being unmodulated;

d) the input current **17** comprising the modulated signal and unmodulated background being fed to an integrator;

e) so that the signal being accumulated while the background being cancelled;

f) so that the signal to noise ratio and dynamic range can be greatly improved.

2) The method of using MIFPA for the detection of extremely weak signals for imaging, spectroscopy, and spectroscopic imaging, which comprises the following steps:

a) a lens or lens system **12** is placed between the scene or object **10** for imaging, spectroscopy, or spectroscopic imaging and the multicycle integration focal plane array (MIFPA) **13**, composed of either one- or two-dimensional of photodetectors **16**, where the image and or spectroscopic signal is collected;

b) a passive optical modulator **11**, which can be a mechanic chopper, an electric-optical switch, a polarizer, or other devices, is placed between the scene or object **10** and the FPA **13** to modulate the photon flux from the aforesaid scene or object **10** for imaging, spectrum, or spectroscopic imaging;

c) or an active modulator, such as a pulsed light source **15**, is used to generate modulated image and/or spectroscopic signals;

d) when the modulator is on in one phase (ϕ1 in the figure), the current generated by the detector **17** is the signal photocurrent I_s from object or scene **10**, plus the DC background current I_b from the radiation **14** not modulated;

e) when the radiation from the imaging target is blocked by the modulator in another phase ϕ2, only the DC I_b is present;

f) by controlling the correlated multicycle integrator synchronically with the modulation control signal, using the same correlated controller **28**, the integrator **30** charges the capacitor with the signal and background currents in ϕ1, but discharges it with background current only in ϕ2;

g) so that the output of **30** is accumulated signal current I_s only (plus the shot noise that is not avoidable);

h) so that the aforesaid accumulated signal current I_s can be fed to any commercial amplifier and/or display for image, spectrum, or spectral imaging using conventional imaging and/or spectroscopic methods.

3) Lock-in multicycle integration focal plane array (LI-MIFPA), linear or area, which is a special type of multicycle integration focal plane array (MIFPA), linear or area, comprising:

a) all the features of claim 1;

b) with the signal accumulation phase ϕ1 and background cancellation phase ϕ2 strictly equal in time.

4) The method of using LI-MIFPA for the detection of extremely weak signals for imaging, spectroscopy, and spectroscopic imaging, which comprises the following steps:

a) all the steps in claim 2;

b) with the signal accumulation phase ϕ1 and background cancellation phase ϕ2 strictly equal in time.

5) Gated multicycle integration focal plane array (G-FPA), linear or area, which is a special type of multicycle integration focal plane array (MIFPA), linear or area, comprising:

a) all the features of claim 1;

b) with $\phi 1$ lasting an interval of $\alpha\tau$, $\phi 2$ lasting an interval of 0 time, and a new phase $\phi 3$ lasting an interval of $(1-\alpha)\tau$

c) wherein during phase $\phi 3$ the integrator **30** is turned off;

d) wherein $\alpha << 1$, or $(1-\alpha)\tau >> \tau$.

6) The method of using G-MIFPA for the detection of extremely weak signals for imaging, spectroscopy, and spectroscopic imaging, under the condition that the signal duty cycle α is extremely small while the background current is not extremely large, namely $\alpha << 1$, while I_s not $<< I_b$, as in some types of IR fluorescence spectroscopy using nano-second pulse laser excitation, which comprises:

a) all the steps in claim 2;

b) with $\phi 1$ lasting an interval of $\alpha\tau$, $\phi 2$ lasting an interval of 0 time, and a new phase $\phi 3$ lasting an interval of $(1-\alpha)\tau$

c) wherein during phase $\phi 3$ the integrator **30** is turned off;

d) wherein $\alpha << 1$, or $(1-\alpha)\tau >> \tau$.

7) Gated lock-in multicycle integration focal plane array (GLI-MIFPA), linear or area, which is a special type of multicycle integration focal plane array (MIFPA), linear or area, comprising:

a) all the features of claim 1;

b) with $\phi 1$ lasting an interval of $\alpha\tau$, $\phi 2$ lasting an equal interval of $\alpha\tau$, and a new phase $\phi 3$ lasting an interval of $(1-2\alpha)\tau$

c) wherein during phase $\phi 3$ the integrator **30** is turned off;

d) wherein $\alpha << 1$, or $(1-2\alpha)\tau >> \tau$.

8) The method of using GLI-MIFPA for the detection of extremely weak signals for imaging, spectroscopy, and spectroscopic imaging, under the condition that the signal duty cycle α is extremely small and the background current is extremely large, namely $\alpha << 1$, and $I_s << I_b$, as in some types of IR fluorescence spectroscopy using nano-second pulse laser excitation, which comprises :

a) all the steps of claim 2;

b) with $\phi 1$ lasting an interval of $\alpha\tau$, $\phi 2$ lasting an equal interval of $\alpha\tau$, and a new phase $\phi 3$ lasting an interval of $(1- 2\alpha)\tau$

c) wherein during phase $\phi 3$ the integrator **30** is turned off;

d) wherein $\alpha << 1$, or $(1- 2\alpha)\tau >> \tau$.